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An update of River Darter (*Percina shumardi*) distribution, relative abundance, life history traits, diet and habitat in Canadian waters

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

The River Darter (*Percina shumardi*) is a native, cryptic fish that has been collected haphazardly in central Canada in relatively small numbers since the 1930s. It has a wide geographic distribution, and in Canada populations of River Darter are found in Manitoba, Ontario and Saskatchewan in three National Freshwater Biogeographic Zones – Saskatchewan-Nelson River, Southern Hudson Bay-James Bay, and Great Lakes-Upper St. Lawrence. As many of the Canadian records of River Darter are quite old, in preparation for the status report Fisheries and Oceans Canada (DFO) revisited many of the historic sites and sampled additional areas where possible to confirm and update the distribution of River Darter in Canadian waters, assess relative abundance, update life history characteristics, diet information, and identify characteristics of River Darter habitat. Over one thousand (1032) River Darters were captured in 29 waterbodies throughout the species' historic range, in relatively high abundance in both the Saskatchewan-Nelson River and Southern Hudson Bay-James Bay biogeographic zones. While still extant in the Great Lakes-Upper St. Lawrence zone, River Darter exist at very low abundance. River Darter in Canadian waters possess similar life history traits and select comparable prey as conspecific populations located in the United States. River Darter reach maturity after their first winter, grow to approximately 40 mm in their first year and slowly thereafter with growth of 10 mm·y. River Darter in these populations live up to 4 years and eat a wide variety of aquatic prey (e.g., chironomids, caddisflies, mayflies, snails and zooplankton). River Darter is a benthic species found in a wide variety of habitats including lotic and lentic waters at varying depths.

Mise à jour sur l'aire de répartition, l'abondance relative, les caractéristiques du cycle biologique, le régime alimentaire et l'habitat du dard de rivière (*Percina shumardi*) dans les eaux canadiennes

RÉSUMÉ

Le dard de rivière (*Percina shumardi*) est un poisson indigène cryptique qui a été capturé accidentellement en relativement petit nombre dans le centre du Canada depuis les années 1930. Il occupe une vaste aire de répartition et les populations canadiennes de dard de rivière se trouvent au Manitoba, en Ontario et en Saskatchewan, dans trois zones biogéograhiques nationales d'eau douce : rivières Saskatchewan-Nelson, sud de la baie d'Hudson-baie James et Grands lacs-Saint-Laurent supérieur. Dans la mesure où de nombreuses données canadiennes sur le dard de rivière sont plutôt anciennes, Pêches et Océans Canada (MPO) a procédé à l'échantillonnage de beaucoup de sites passés et d'autres zones lorsque c'était possible afin de confirmer et de mettre à jour l'aire de répartition de l'espèce dans les eaux canadiennes, d'en évaluer l'abondance relative, de mettre à jour les caractéristiques de son cycle biologique et les données sur son régime alimentaire, et enfin de déterminer les composantes de son habitat. Plus d'un millier (1 032) de dards de rivière ont été capturés dans 29 cours d'eau de l'aire de répartition historique de l'espèce, et ils se trouvent en abondance relativement élevée dans les deux régions biogéographiques des rivières Saskatchewan-Nelson et du sud de la baie d'Hudson-baie James. Le dard de rivière est encore présent dans la zone des Grands Lacs-Saint-Laurent supérieur, mais son abondance y est très faible. Les populations de dard de rivière présentes dans les eaux canadiennes possèdent les mêmes caractéristiques du cycle biologique que les populations conspécifiques qui se trouvent aux États-Unis, et elles se nourrissent d'espèces de proies semblables. Le dard de rivière atteint la maturité après son premier hiver, croît jusqu'à environ 40 mm pendant la première année, puis plus lentement par la suite à un rythme de 10 mm par an. Ces populations peuvent vivre jusqu'à quatre ans et se nourrissent d'une grande variété de proies aquatiques (p. ex., chironomes, phryganes, éphéméroptères, escargots et zooplancton). Le dard de rivière est une espèce benthique présente dans de nombreux habitats différents, notamment les eaux lotiques et lentiques, à diverses profondeurs.

INTRODUCTION

The River Darter (*Percina shumardi*) is a native, cryptic fish that has been collected haphazardly in central Canada in relatively small numbers since the 1930s. The species has a wide North American geographic distribution, ranging from Texas northward to northern Manitoba, and from the Saskatchewan River in the west to as far east as the Ohio River in Pennsylvania (Scott and Crossman 1973; Freedman et al. 2009; Page and Burr 2011). In Canada, River Darter is found in major watersheds in Saskatchewan (Saskatchewan River), Manitoba (Assiniboine, Nelson, Red, and Winnipeg river watersheds as well as lakes Dauphin, Manitoba, Winnipegosis, and Winnipeg watersheds) and Ontario (English and Rainy river watersheds that are part of the Nelson River watershed, as well as the Attawapiskat, Albany, Severn and Winisk river watersheds that flow into Hudson or James Bay, and the Lake St. Clair watershed in the Great Lakes drainage). Despite this wide distribution, relatively few individuals have been collected in most areas, and River Darter is a species of conservation concern in many jurisdictions.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has requested an update of the status of River Darter in Canada. Populations of River Darter are found in Manitoba, northwestern Ontario and Saskatchewan in the Saskatchewan-Nelson River Biogeographic Zone (based on the COSEWIC National Freshwater Biogeographic Zone classification; Figure 1) and the Southern Hudson Bay-James Bay Biogeographic Zone. Southern Ontario also has populations in the Great Lakes-Upper St. Lawrence Biogeographic Zone. The Saskatchewan-Nelson River, Southern Hudson Bay-James Bay and Great Lakes-Upper St. Lawrence biogeographic zones are geographically isolated from each other. This document will follow the three biogeographic zone convention to aid in the transfer of information to the COSEWIC process.

As the Department responsible for this species, Fisheries and Oceans Canada (DFO) is required to summarize available information on this species. As many of the Canadian records of River Darter are quite old, in preparation for the COSEWIC status report, DFO revisited many of the historic sites and sampled additional waterbodies, where possible. This manuscript reports on the findings of those targeted surveys, along with incidental captures from across the species range, including an assessment on the distribution of River Darter and its relative abundance, an update of life history characteristics, diet and identification of the characteristics of River Darter habitat.

METHODS

SAMPLING SITES

River Darter were captured by DFO from a number of sites in Manitoba and northwestern Ontario between 1996 and 2014 by trawling, seining, and backpack and boat electrofishing (Tables 1 and 2; Figure 2). River Darter were incidentally captured by DFO in many of the earlier surveys; these captures are reported in Table 1 and displayed in Figure 2 along with known capture locations and DFO sample sites to provide a more complete picture of the species distribution. No additional assessment or analyses were undertaken with these records. River Darter were captured by DFO at two sites in southern Ontario in 2012 and 2014 by trawling (Table 2; Figure 3). Additional DFO trawling sites and known capture locations are also indicated in Figures 2 and 3. From 2012 to 2014, targeted River Darter sampling occurred at 18 sites (Table 2; Figure 2). These assessments are reported on in more detail, and the data from these sampling efforts account for the majority of this manuscript.

FIELD SAMPLING

The majority of the targeted sampling was completed using a 2.5 m wide mini-Missouri bottom trawl (Herzog et al. 2009) to sample suitable areas in both lakes and rivers. Prior to trawling, the depth and substrate of a potential site was assessed using Hummingbird 1198c side-scan sonar to ensure there were no obstacles to trawling. When an area devoid of large rocks and trees not subject to extreme changes in bathymetry was located, the trawl was deployed at the upstream end of the site, GPS coordinates were taken, and the net was pulled with a boat downstream on the bottom at a speed faster than the current. In lakes, the net was either pulled across current or with the current if the waves were higher than 20 cm. At the end of the trawl, GPS coordinates were captured and the net was lifted. Captured fishes were placed into a cooler filled with fresh lake water, identified to species and all by-catch released. In most sites, multiple trawls were conducted to ensure adequate sample sizes for age, growth, life history and genetic assessment. At some of the northwestern Ontario sites, basic water quality data (temperature, pH, turbidity, and dissolved oxygen) were collected using a YSI 6820V2-M multi-parameter water quality sonde.

In the Rainy River, some individuals were collected in 2013 with boat electrofishing during a broader fish community survey. Two Smith-Root SR-14H electrofishing boats were used in addition to the trawl. Both vessels were equipped with a 5-kilowatt gas-powered pulsator producing a pulsed DC current and similar propeller-driven outboards, crewed with three people. Twenty-four, preselected 1.6 km long transects were fished as close to shore as possible. All captured fishes were kept in an onboard live well until the end of the transect when they were identified to species and basic biological information (length, weight) was collected.

LABORATORY SAMPLING

In most sites, approximately 30 River Darter were kept for length, weight, genetic, aging, diet, gender assignment and maturity status (mature, immature, and unknown), when possible. In the Rainy River, nearly all captured individuals were kept. Samples were preserved in 70% ethanol and brought back to the lab for processing. One or two specimens from most sites were sent to the Royal Ontario Museum for identification validation and archiving, so there is limited data (length, weight) available for these individuals. Stomach contents were examined to the family level, or to order if family identification features were unidentifiable.

Sagittal otoliths were removed for age and growth assessment. The otoliths were prepared by first cleaning them with three consecutive 10 minute baths of 10% bleach, de-ionized water, and 70% ethanol. When dry they were mounted in a resin epoxy (Cold Cure™) and left to dry for 24 hours. 3M Wetordry™ 1000 sandpaper was used to sand the otolith/resin plug until the sagittal face was smooth. The otolith was then scored and dyed by dipping it in a 5% aqueous solution of NAOH and a 0.01% aqueous solution of Toluidine Blue. An Olympus SZX16 microscope and an Olympus Q-Color 5 digital camera were used to observe and photograph the otolith images. Two agers, working independently, viewed the digital photos and assigned ages to each photo. In situations where the agers did not agree on the ages, a third ager examined the photos and assigned an age.

DATA ANALYSIS

Densities were calculated by assuming trawls and boat electrofishers had an effective sampling width of 2.5 m. Densities (number/ha) were then estimated by determining the mean number of River Darter captured per m^2 by 10,000, as there are 10,000 m^2 in a hectare. A nested Analysis of Variance, with sampling sites nested within biogeographic zones, was performed to examine for differences in mean density across zones and among sampling sites. The fall 2013 trawl

data were used to represent the multiple collections from the Rainy River in this analysis. Mean densities were ln (x+1) transformed in this analysis to meet the assumptions of parametric statistics. Tukey HSD tests were used to separate sites when significant differences were detected (Zar 1999).

RESULTS

River Darter were collected in 29 lakes and rivers, including the vast majority of historical sites surveyed (Tables 1 and 2). Only the Balne River watershed had a historic sampling record that was not replicated in our surveys. River Darter were captured in all three biogeographic zones that were sampled; the Saskatchewan-Nelson, Southern Hudson Bay-James Bay and Great Lakes-Upper St. Lawrence. These included some large watersheds in the Saskatchewan-Nelson biogeographic zone such as the Rainy, Winnipeg, English and Assiniboine river, and Lake Winnipeg, Dauphin Lake and Lake Winnipegosis watersheds (Figure 2). Fewer collections were made in the Southern Hudson Bay-James Bay biogeographic zone (the Albany and Attiwapiskat river watersheds) and Great Lakes-Upper St. Lawrence biogeographic zone (Lake St. Clair watershed; Figure 3). Our sampling of historic sites was limited by road access (some earlier collections were made by flying into remote locations), but overall we were successful in capturing River Darter in waterbodies where it was earlier found, and expanding the known distribution of the species in some watersheds (Figure 2).

A total of 1031 River Darter were captured during the incidental and targeted surveys (Tables 1 and 2). The majority of these fish were collected on the Assiniboine (402) and Rainy (342) rivers. Five-hundred and eighty-two (582) fish were collected as part of targeted collections that were then used for relative abundance and biological assessments (Table 2). Relatively large collections (> 20 individuals) were made in the Rainy River, Lake of the Woods, English River, Sturgeon River, Assiniboine River, Lake Winnipeg, Lake St. Joseph and Badesdawa Lake (Table 1). Relative abundance varied among sampling sites, with a number of Saskatchewan-Nelson and Southern Hudson Bay-James Bay biogeographic zone sites including Lake Winnipeg, English River, Lake St. Joseph, Badesdawa Lake, Lake of the Woods and Assiniboine River exhibiting relatively high densities (Table 1). Low densities occurred in some sampling sites, most notably the southern Ontario sites (Thames and Sydenham rivers). There were significant differences in mean density among biogeographic zones (Nested ANOVA $F_{2,17} = 4.7$, $P = 0.024$) and sampling sites (Nested ANOVA $F_{17,112} = 1.9$, $P = 0.029$). Mean density in all three biogeographic zones were different from each other, with the Great Lakes-Upper St. Lawrence biogeographic zone having the lowest mean density and the Southern Hudson Bay-James Bay biogeographic zone having the highest mean density (Figure 4). The mean density of River Darter on the lower English River, Lake St. Joseph and the Assiniboine River were significantly higher than the Thames and Sydenham rivers, and Lake St. Joseph also had higher densities than the Balne River and Red Lake.

Mean length and weight varied among waterbodies and appeared influenced by sample date, as late summer and fall collections contained many small age-0 individuals (Table 3). The Assiniboine and Rainy rivers contained the largest individuals and had the greatest age range of any of the populations (Table 3; Figure 5). Age-0 fish were prominent in all the late-summer/fall collections, making up the vast majority of individuals captured in many sites. Growth in the Saskatchewan-Nelson biogeographic zone appears relatively linear (Figure 5), with fish growing at approximately 10 mm·year. Growth in the Saskatchewan-Nelson biogeographic zone is faster than growth in the Southern Hudson Bay-James Bay biogeographic zone for age-0 and age-1 fish (Figure 6); no fish older than age-1 were collected from the Southern Hudson Bay-James Bay biogeographic zone.

It was generally possible to identify the gender of fish age-1 and older, suggesting that the River Darter in these collections mature after their first winter. Sex ratios were highly skewed towards female dominance (Table 3), with only the populations in the Sturgeon River and Badesdawa Lake demonstrating balanced sex ratios.

Stomach content assessment indicated that River Darter utilizes a wide prey base, likely reflecting the dynamic habitat conditions (lotic vs lentic, spring vs fall) under which the sampling occurred. While each waterbody appeared to have its own somewhat unique prey base, in the June samples, certain diet items were common among sites including chironomids (Chironomidae), caddisflies (Hydropsychidae, Polycentropodidae, Trichoptera) and mayflies (Ephemereliidae, Heptageniidae, Leptophlebiidea, and Ephemeroptera; Table 4). Chironomids, mayflies and caddisflies were also present in fall diets, but other prey items, notably zooplankton (Cladocera, Zooplankton) and snails (Lymnaeidae, Gastropoda) also became important diet items (Table 4).

River Darter were captured in a wide variety of habitats. This included multiple collections from both lotic and lentic waterbodies. In targeted, 2014 sampling efforts, River Darter were collected at a depth range from 2 – 5 m, with water temperatures ranging 8.5 – 15.6 °C, and turbidity ranging 0.4 – 6.4 NTUs (Table 5). pH levels and dissolved oxygen concentrations at sampling time were well within the range of tolerance for coolwater fishes (Table 5). Habitat data were also available for many of the incidental River Darter collections from the Assiniboine River, in depths ranging 0.28 – 3.0 m, velocities 0.02 – 0.99 m/sec, and temperatures 20.5 – 25.9 °C.

DISCUSSION

These collections demonstrate that River Darter continues to be broadly distributed throughout its historic range, and are present in more sites and at a higher abundance than was previously believed. A similar expansion of the known distribution of River Darter occurred recently in Pennsylvania when trawls were employed in the upper portion of the Ohio River (Freedman et al. 2009). River Darter are benthic, small-bodied, cryptic fish and can be most abundant in non-wadeable streams. Bottom trawling is the preferred sampling gear as other sampling gears are poorly suited to sample small bodied fish in these habitats. The most northern historic sites are not road accessible, so it was not possible to re-sample those areas given the limited budget of this project. Therefore, the current status of River Darter in those sites is not known.

Relatively robust River Darter populations were apparent in a number of lakes and rivers. Dalton (1990) suggested that River Darter were not abundant in Canada, with the largest collection at that time being 10 specimens. However, River Darter is locally abundant in large, turbid rivers in the United States (Cooper 1983, Kuehne and Barbour 1983, Page 1983, Warren et al. 2000, Page and Burr 2011). These surveys resulted in many collections with more than 10 specimens, which indicate that River Darter is likely more common in Canadian waters than originally believed. The higher catches are likely a result of using a gear (trawling) that was more conducive to sampling River Darter than seines or electrofishing. These large collections in the core of the species Canadian range (southern Manitoba and northwestern Ontario) suggest that River Darter populations remain healthy in at least two of the DUs (Saskatchewan-Nelson and Southern Hudson Bay-James Bay) in their Canadian range. This is likely not the case for the Great Lakes-Upper St. Lawrence DU, where very few individuals have been collected despite significant trawling effort in rivers where River Darter records exist.

Prior to this assessment, the biology of River Darter in Canadian populations was poorly known. In Illinois, River Darter mature as early as age 1 and reach a maximum age 3 (Thomas 1970) or age 4 (Smith 1979). The same age-at-maturity (1) and maximum age (4) were apparent in the populations assessed in this study, indicating that these life history traits are common across

the species range. River Darter in Manitoba and northwestern Ontario grow slowly, adding approximately 10 mm·year in length. No other estimates of annual growth were available in the literature. River Darter also generally appears to have a skewed sex ratio, with a predominance of females in most of the assessed populations. This phenomenon is found in many fishes, and there are a number of explanations for differential survival of the sexes including increased mortality due to predation, differences in growth rate and an associated survival trade-off, or differences in reproductive activity or maturation schedule (Bunnell et al. 2006). The high female dominance may indicate poor recent recruitment events for these River Darter populations.

Diet patterns observed in this assessment were consistent with the River Darter diet literature. River Darter feed primarily during daylight hours and consumes a wide variety of food items that changes seasonally (Thomas 1970, Balesic 1971). In Illinois and Manitoba, stomach contents included Diptera, Trichoptera, Ephemeroptera, Crustacae and fish eggs (Thomas 1970, Balesic 1971). A similar wide breadth of diet and seasonal influences were observed in this assessment. In addition to Diptera, Trichoptera, Ephemeroptera, which were dominant spring prey items, zooplankton became an important diet item in fall-sampled sites. This shift might reflect prey availability, or the high proportion of smaller, age-0 River Darter present in the fall samples. In Alabama and Tennessee, snails can be an important component of River Darter diet, varying seasonally with availability (Starnes 1977, Haag and Warren 2006). They also were consumed by River Darter collected in September in Manitoba (Balesic 1971). Snails were also important prey items in the fall in some sites in this study.

Unlike many darter species that have specialized habitat niches, River Darter appear to be more broadly tolerant of a variety of habitat conditions. The findings of our targeted surveys concurred with the knowledge that River Darter populations occur in both rivers and lakes. Through much of its range, River Darter is associated with a variety of substrates, moderate currents and deeper water (Thomas 1970, Pfleiger 1971, Scott and Crossman 1973, Becker 1983, Kuehne and Barbour 1983). In our targeted surveys, River Darter was collected most frequently in moderate water velocities in rivers and at a wide range of depths in both rivers and lakes. River Darter is tolerant of turbid waters (Balesic 1971, Pfleiger 1971, Cooper 1983, Sanders and Yoder 1989) and are a common, if not the most common, darter in turbid rivers (Cooper 1983, Kuehne and Barbour 1983). Similarly, River Darter was collected over a wide range of turbidities in this survey, including large numbers in the turbid Assiniboine River.

In summary, this manuscript provides an important update on the distribution of River Darter in its Canadian range. It provides the first relative density estimates available for the species, and confirms that River Darter in Canadian waters possess similar life history traits and select comparable prey as conspecific populations located in the United States.

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TABLES AND FIGURES

Table 1. Sampling site and date, biogeographic zone, gear type and the number of River Darter captured by DFO for surveys where River Darter were incidentally captured. Whether River Darter was previously found at that site is also indicated.

Biogeographic zone	Waterbody	Latitude and Longitude	Historic site	Date(s)	Gear type	Number captured
Saskatchewan-Nelson	Assiniboine River	Captures from 99 sites	Yes	28/08/1996 to 23/07/2009	trawl and boat efishing	366
Saskatchewan-Nelson	Bird Lake / Bird River	50°28.984; -95°15.981	New	14/08/2003 to 02/10/2003	boat efishing	19
Saskatchewan-Nelson	Boundary Creek	50°30.521, -96°58.537	New	23/06/2004	backpack efishing	1
Saskatchewan-Nelson	Crowduck Lake	50°06.389; -95°16.198	New	01/09/2009 and 02/09/2009	seine	4
Saskatchewan-Nelson	Icelandic River	50°57.887, -97°02.329	New	16/07/2004	backpack efishing	1
Saskatchewan-Nelson	La Salle River	49°41.659, -97°15.748	New	17/04/2002	backpack efishing	1
Saskatchewan-Nelson	Lake Winnipeg	51°47.315; -96°52.347	Yes	27/07/2006	trawl	1
Saskatchewan-Nelson	Manigotogan River	51°06.091; -96°17.029	Yes	03/09/2003	boat efishing	9
Saskatchewan-Nelson	Norquay Channel	49°31.921, -97°51.847	New	28/05/2002	backpack efishing	4
Saskatchewan-Nelson	Ochre River	50°54.266; -99°49.150	New	10/05/1999	unknown	1
Saskatchewan-Nelson	Ochre River	51°03.083, -99°47.192	New	23/07/2002	backpack efishing	4
Saskatchewan-Nelson	Rainy River	48°38.677; -94°05.680	Yes	28/07/2004	boat efishing	2

Biogeographic zone	Waterbody	Latitude and Longitude	Historic site	Date(s)	Gear type	Number captured
Saskatchewan-Nelson	Riviere Aux Marais	49°08.004, -97°17.523	New	23/07/2003	backpack efishing	1
Saskatchewan-Nelson	Seine River Diversion	49°41.840, -97°05.985	New	30/07/2004	backpack efishing	18
Saskatchewan-Nelson	Swan River	52°13.668, -100°59.552	New	05/08/2004	backpack efishing	10
Saskatchewan-Nelson	Unnamed tributary to Boyne River	49°32.464, -98°24.885	New	27/08/2002	backpack efishing	1
Saskatchewan-Nelson	Wilson River	51°11.973, -100°06.277	New	30/06/2004	backpack efishing	1
Saskatchewan-Nelson	Winnipeg River	50°13.373; -95°34.397	Yes	15/09/2003 and 16/09/2003	boat efishing	2
Saskatchewan-Nelson	Vermillion River	51°10.185, -100°03.225	New	20/07/2004	backpack efishing	3

Table 2. Sampling site and date, biogeographic zone, gear type and effort (number of trawls or efishing transects), the number of individuals captured, and mean density (± standard error) from recent, DFO-led targeted River Darter surveys. Whether River Darter was previously found at that site is also indicated.

Biogeographic zone	Waterbody	Latitude and Longitude	Historic site	Date(s)	Gear type	Effort	Mean length (m)	River Darter captured	Density (fish/ha)
Saskatchewan-Nelson	Rainy River	48°34.155; -93°27.610	Yes	19/06/2013 to 22/06/2013	trawl	60	306.0	152	52.0 (11.3)
		48°30.926; -93°40.764		08/08/2013 to 13/08/2013	boat efishing	24	1609.3	168	17.4 (7.2)
		48°32.474; -93°30.261		11/09/2013 to 12/09/2013	trawl	12	282.0	17	20.7 (8.6)
		48°31.687; -93°35.274		13/06/2014	trawl	2	365.0	3	10.3 (10.3)
Saskatchewan-Nelson	Lake of the Woods	48°58.276; -94°33.213	Yes	13/06/2014	trawl	5	174.8	21	97.5 (65.6)
Saskatchewan-Nelson	Balne River	49°48.933; -94°13.300	Yes	14/06/2014	trawl	4	151.8	0	-
Saskatchewan-Nelson	Red Lake	51°05.279; -93°48.536	Yes	15/06/2014	trawl	7	121.0	1	8.1 (8.1)
Saskatchewan-Nelson	Chukini River	50°56.117; -93°36.264	New	16/06/2014	trawl	3	173.3	5	43.9 (32.2)
Saskatchewan-Nelson	English River (lower and upper)	50°37.531; -93°15.808	Yes	16/06/2014	trawl	5	134.2	27	140.4 (53.5)
		49°38.028; -91°21.913		13/09/2014	trawl	6	273.3	17	37.6 (20.4)
Saskatchewan-Nelson	Barnston Lake	50°34.567; -93°28.223	Yes	16/06/2014	trawl	1	220.0	1	18.8 (-)

Biogeographic zone	Waterbody	Latitude and Longitude	Historic site	Date(s)	Gear type	Effort	Mean length (m)	River Darter captured	Density (fish/ha)
Saskatchewan-Nelson	Barrel Lake	49°39.468; -91°29.369	Yes	19/06/2014	trawl	2	215.0	1	11.8 (11.8)
Saskatchewan-Nelson	Sturgeon River	50°06.886; -91°43.192	New	14/09/2014	trawl	5	411.2	26	49.5 (20.2)
Saskatchewan-Nelson	Lac Seul	50°12.163; -91°50.705	Yes	14/09/2014	trawl	4	330.0	2	8.8 (5.4)
Saskatchewan-Nelson	Little Turtle Lake	48°46.804; -92°36.968	New	16/09/2014	trawl	1	570.0	1	7.0 (-)
Saskatchewan-Nelson	Niobe Lake	48°43.631; -91°19.549	N/A	16/09/2014	trawl	1	380.0	0	-
Saskatchewan-Nelson	Assiniboine River	49°42.245; -99°40.109	Yes	09/10/2014	trawl	8	169.9	36	96.8 (40.4)
Saskatchewan-Nelson	Lake Winnipeg	51°07.195; -96°21.271	Yes	08/10/2014	trawl	10	66.0	33	182.1 (12.5)
Southern Hudson Bay-James Bay	Lake St. Joseph	51°05.877; -90°17.529	Yes	12/09/2014	trawl	4	305.0	30	117.8 (68.5)
Southern Hudson Bay-James Bay	Badesdawa Lake	51°43.728; -89°46.994	New	12/09/2014	trawl	3	306.7	38	109.7 (55.5)
Great Lakes-Upper St. Lawrence	Pine River	48°02.615; -89°30.579	N/A	17/09/2014	trawl	1	730.0	0	-
Great Lakes-Upper St. Lawrence	Thames River	42°36.586; -81°49.170	Yes	24/06/2014 to 26/06/2014	trawl	26	100.0	1	1.5 (1.5)
Great Lakes-Upper St. Lawrence	Sydenham River	42°35.887; -82°21.545	Yes	20/09/2012	trawl	24	100.0	2	3.3 (2.3)

Table 3. Mean total length (l_t) and length range (mm), mean weight (g) and sex ratio for River Darter captured and assessed from DFO-led surveys. Numbers in brackets represent ± standard error.

Waterbody	Date(s)	Sample size for l_t and weight	Mean l_t (mm)	Length range (mm)	Mean weight (g)	Sex ratio	Sample size for aging	Mean age (yrs)	Age range
Rainy River	19/06/2013 to 22/06/2013	145 (l); 144 (w)	53.0 (0.4)	43-67.5	1.2 (0.04)	6♂:71♀	98	2.6	1-4
	08/08/2013 to 13/08/2013	167	42.5 (0.7)	30-72	0.6 (0.04)		65	0.7	0-3
	11/09/2013 to 12/09/2013	16	46.7 (1.9)	40-64.5	0.8 (0.12)	3♂:13♀	9	2.1	1-3
Lake of the Woods	13/06/2014	17	43.6 (0.5)	40-47	0.6 (0.02)	4♂:11♀	13	1.4	1-2
Red Lake	15/06/2014	1	42		0.43	0♂:1♀	1	1	
Chukini River	16/06/2014	5	42.4 (1.8)	37-48	0.6 (0.07)	1♂:1♀	4	1.8	1-2
English River	16/06/2014	27	41.4 (0.6)	35-47	0.5 (0.03)	7♂:17♀	25	1.2	1-2
	13/09/2014	17	40.3 (1.6)	30-53	0.5 (0.06)	2♂:14♀	15	0.6	0-3
Barnston Lake	16/06/2014	1	41		0.38				
Barrel Lake	19/06/2014	1	48.5		0.5				
Sturgeon River	14/09/2014	26	42.3 (1.4)	35-60	0.7 (0.09)	13♂:11♀	21	0.4	0-3
Lac Seul	14/09/2014	1	30		0.2				
Little Turtle Lake	16/09/2014	1	41		0.5				
Assiniboine River	09/10/2014	36	69.3 (1.4)	48-93	2.9 (0.20)	0♂:35♀	36	2.8	1-4
Lake Winnipeg	08/10/2014	31	43.5 (1.6)	33-66	0.7 (0.10)	8♂:18♀	31	0.8	0-3
Lake St. Joseph	12/09/2014	30	33.9 (0.6)	30-40	0.3 (0.02)	8♂:17♀	27	0.1	0-1
Badesdawa Lake	12/09/2014	32	36.1 (0.4)	32-43	0.3 (0.01)	11♂:14♀	22	0.3	0-1

Table 4. Most common diet items in the stomach contents of ten River Darter populations collected in 2013-2014.

Waterbody	Date(s)	Top Diet Items		
Rainy River	19/06/2013 to 22/06/2013	Hydropsychidae	Ephemereliidae	Chironomidae
Lake of the Woods	13/06/2014	Chironomidae	Heptageniidae	Hydropsychidae
Red Lake	15/06/2014	Trichoptera	Copepoda	Chironomidae
Chukini River	16/06/2014	Chironomidae	Trichoptera	Cladocera
English River	16/06/2014	Chironomidae	Trichoptera	Ephemeroptera
	13/09/2014	Zooplankton	Chironomidae	Leptophlebiidea
Sturgeon River	14/09/2014	Chaoboridae	Chironomidae	Polycentropodidae
Assiniboine River	09/10/2014	Hydropsychidae	Heptageniidae	Lymnaeidae
Lake Winnipeg	08/10/2014	Chironomidae	Lymnaeidae	Ephemeroptera
Lake St. Joseph	12/09/2014	Cladocera	Zooplankton	Amphipods
Badesdawa Lake	12/09/2014	Gastropoda	Zooplankton	Cladocera

Table 5. Mean measured habitat parameters, including depth, temperature, pH, turbidity, and dissolved oxygen, from selected River Darter collection sites.

Waterbody	Date(s)	Depth (m)	Temperature (°C)	pH	Turbidity (NTUs)	Dissolved oxygen (mg/L)
Lake of the Woods	13/06/2014	3.7	15.63	7.55	6.3	9.12
Red Lake	15/06/2014	3.4	8.52	7.51	0.4	10.39
Chukini River	16/06/2014	3.6	10.78	7.56	2.5	9.59
English River	16/06/2014	3.5	12.65	7.71	5.6	10.16
	13/09/2014	4.6	14.07	8.10	1.2	9.63
Barnston Lake	16/06/2014	3.0	13.79	7.56	5.8	10.03
Barrel Lake	19/06/2014	3.8	15.41	7.62	1.3	9.02
Lake St. Joseph	12/09/2014	4.8	14.44	7.10	1.3	9.67
Badesdawa Lake	12/09/2014	2.5	10.45	7.91	3.1	10.54
Sturgeon River	14/09/2014	5.0	14.56	8.02	1.1	10.01
Lac Seul	14/09/2014	4.2	13.32	7.89	1.7	9.17
Little Turtle Lake	16/09/2014	2.0	12.96	7.80	5.8	9.90

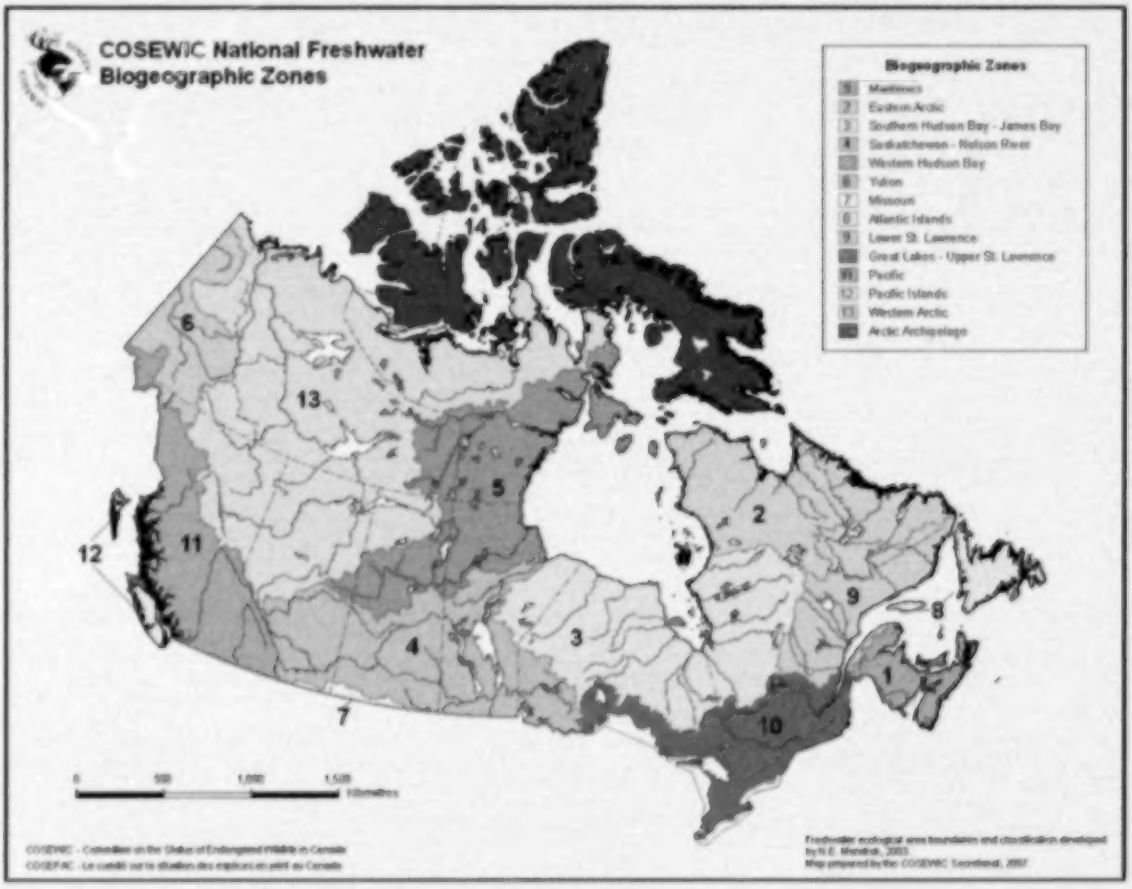
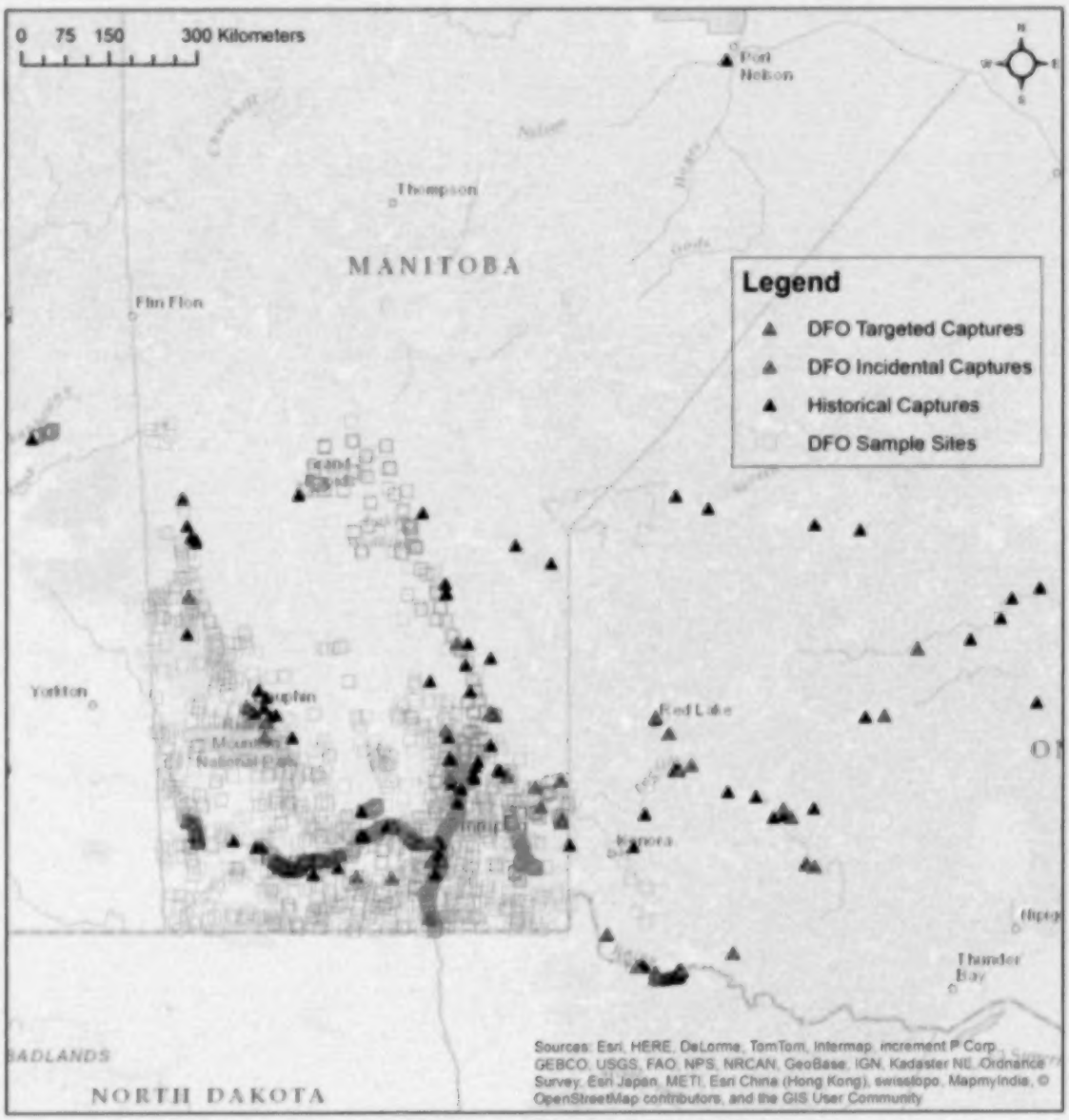


Figure 1. COSEWIC National Freshwater Biogeographic Zones.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Port Nelson
Thompson
MANITOBA
Flin Flon
Legend
DFO Targeted Captures
DFO Incidental Captures
Historical Captures
DFO Sample Sites
Yorkton
Red Lake
Kenora
Thunder Bay
BADLANDS
NORTH DAKOTA
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 2. Locations of River Darter collections in Manitoba and northwestern Ontario.

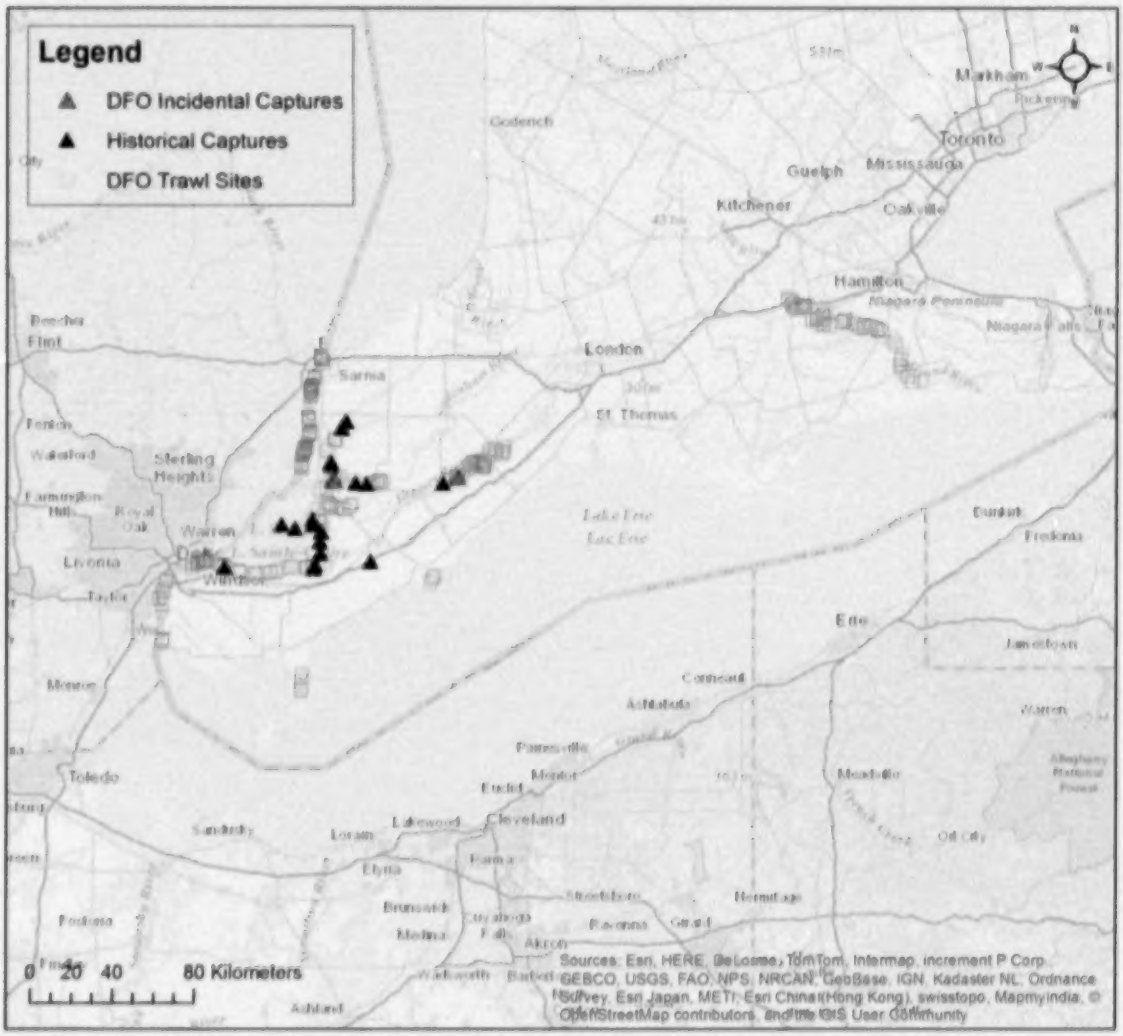

Figure 3. Locations of River Darter collections in southern Ontario.

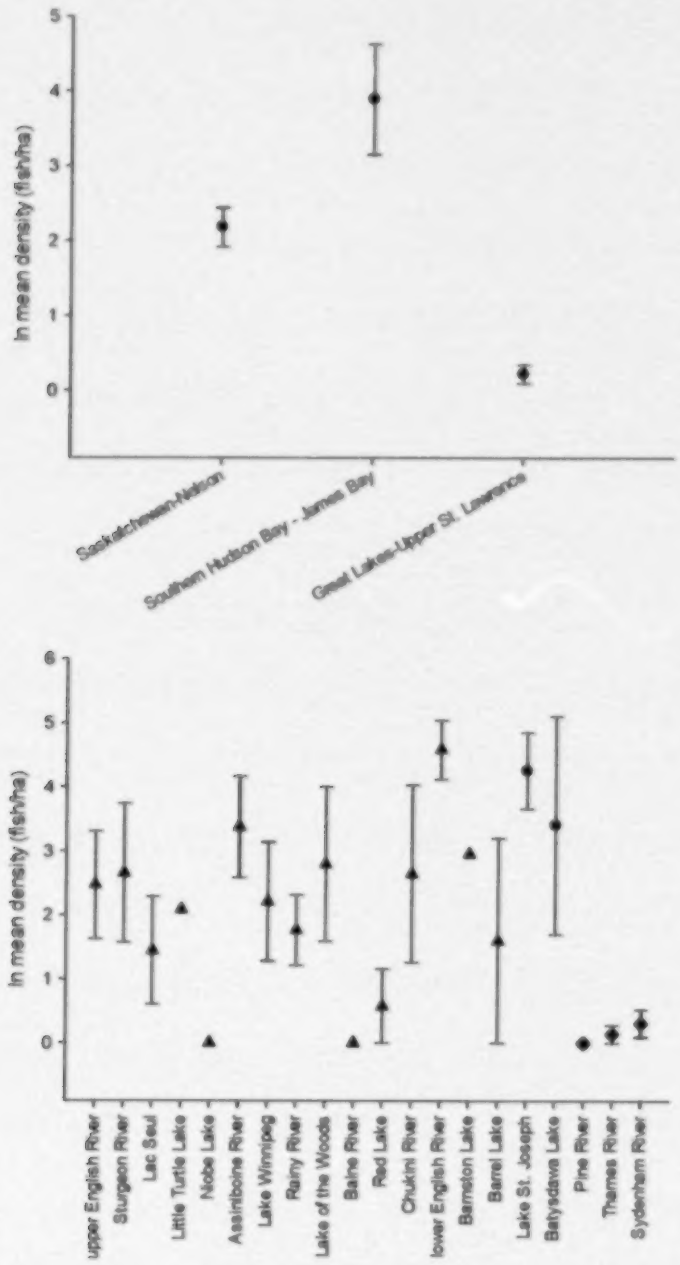

Figure 4. Mean River Darter density from three biogeographic zones (top panel) and individual sites (bottom panel) recently (2012-2014) sampled by DFO. The Saskatchewan-Nelson River biogeographic zone (▲ in lower panel) is represented by the fifteen 2014 sampling sites (64 trawls); Southern Hudson Bay-James Bay biogeographic zone (● in lower panel) is represented by two sites (7 trawls); and Great Lakes-Upper St. Lawrence biogeographic zone (♦ in lower panel) is represented by three sites (8 trawls). Error bars represent ± standard error.

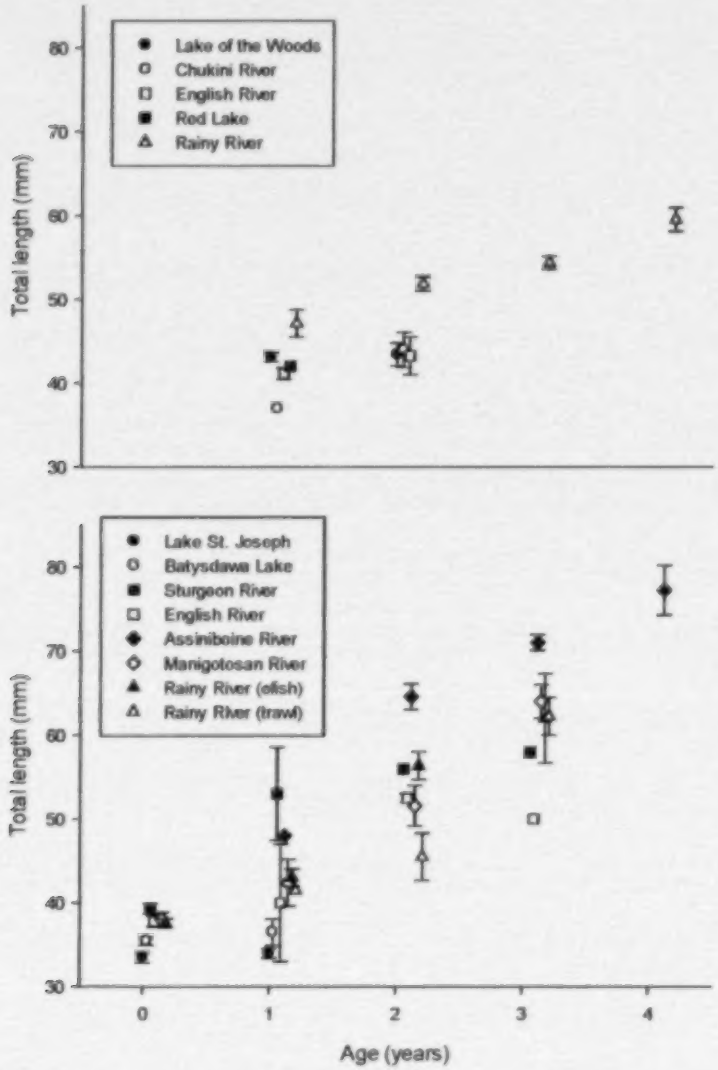

Figure 5. Mean length-at-age for River Darter collected from sites recently (2012-2014) sampled by DFO in the spring (top panel) and the fall (bottom panel). Error bars represent ± standard error.

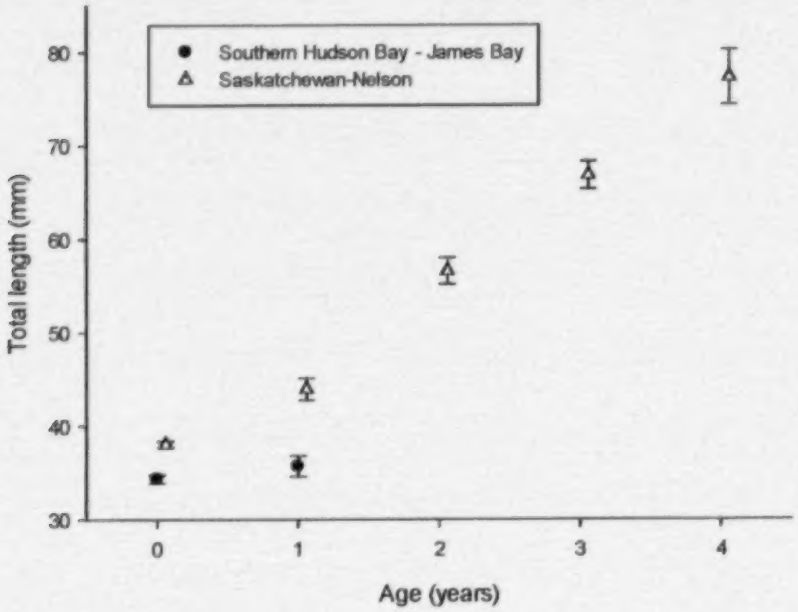

Figure 6. Mean length-at-age for River Darter sampled from two biogeographic zones, Southern Hudson Bay-James Bay and Saskatchewan-Nelson River, in the fall of 2013-2014. Error bars represent ± standard error.